CERTIFICATION OF ENGLISH LANGUAGE TRANSLATION OF PRIORITY DOCUMENT

I, Kentaro Higuchi, hereby declare and state that I am knowledgeable of each of the Japanese and English languages. I hereby certify that the attached English language translation is a complete and accurate translation of Japanese Patent Application Number 10-227065 entitled Position Detecting Device and Exposure Device.

September 23, 2002
Date

Signature

Kentaro Higuchi
Typed Name

[Name of Document] Specification

[Title of the Invention] Stage Device and Exposure Device

[Scope of Claims]

[Claim 1]

A position detecting device for detecting a position of a stage based on a light beam reflected on a fixed mirror arranged in a reference unit and a light beam reflected on a moving mirror arranged on a movable stage, comprising:

correction means for correcting errors originated from vibrations of the fixed mirror; and

control means for controlling the stage based on an output from the correction means.

[Claim 2]

The position detecting device of claim 1, wherein the correction means is a low pass filter.

[Claim 3]

The position detecting device of claim 1, wherein the correction means corrects the error based on a stage instruction signal instructing the driving of the stage.

[Claim 4]

An exposure device for exposing a pattern of a mask onto a substrate, comprising:

a mask stage on which the mask is placed; and

a substrate stage on which the substrate is placed;

wherein the position detecting device of any one of claims 1-3 is used for a position detecting device that detects a position of at least one of the mask stage and the substrate stage.

[Claim 5]

The exposure device of claim 4, wherein an image of the pattern is projected on the substrate by a projection optical system, and the fixed mirror is arranged on the projection optical system.

[Detailed Description of the Invention]

[0001]

[Industrial Field of Invention]

The present invention relates to position detecting devices for detecting positions of movable stages. In particular, the present invention relates to position detecting devices suitable for a stage of an exposure device used for the manufacture of liquid crystal display

elements, integrated circuit elements, thin film magnetic heads, etc., and exposure devices that use such position detection devices.

[0002]

[Conventional Art]

To manufacture a large liquid crystal panel (liquid crystal display substrate) and a large semiconductor element and the like, for example, with high throughput, a scan type exposure device has been known which successively exposes a pattern on a mask onto a plate by illuminating an illumination region of a slit shape (rectangular shape or circular arc shape) on a mask (photomask, reticle, etc.), scanning the mask in the direction of the short side with respect to the illumination region, and synchronously scanning the substrate (glass plate, semiconductor wafer, etc.) on which a photoresist is applied, with respect to the exposure region conjugate with the illumination region.

[0003]

FIG. 2 shows an example of a scanning type exposure device. In particular, an illuminating optical system 1 and a projection optical system 4 are fixed to a base 10 by means of a B column 8 which is integrated with the base 10. On a carriage 7 for scanning arranged to move freely with respect to base 10, there is located a mask 2 via a mask stage 3 which is movable by a small amount with respect to carriage 7. A substrate 5 is located such that a substrate stage 6 is movable by a small amount with respect to the carriage 7 (the fixed portions are drawn with thick lines, and the movable portions with thin lines). By scanning the carriage 7, the mask 2 and substrate 5 are scanned in a predetermined direction with respect to the projection optical system 4, and the pattern of the mask 2 is successively transferred onto the substrate 5. A laser interferometer 22 is supported by an A column 9, and by means of the interference of light reflected from a fixed mirror 11 arranged in the projection optical system 4 and light reflected from a moving mirror 12 arranged in the substrate stage 6, the position of the substrate stage 6 with respect to the projection optical system 4 is detected. The position information of the substrate stage 6 from the laser interferometer 22 is introduced into the main control device 40. The main control device 40 is equipped with an acceleration/deceleration calculating unit 18 which outputs speed adjustment instructions according to the exposure program. A servo calculating unit 20 calculates and outputs the drive signals for the carriage 7 based on the difference of the speed adjustment instructions and the position information of the substrate stage 6, and a drive amplifier 21 which amplifies the output of the servo operating unit

20. The control unit 17 controls the carriage 7 by means of the output of the drive amplifier 21. The laser interferometer 22, main control device 40 and control unit 17 make up a servo loop that controls the carriage 7. That is, the substrate stage 6 is positioned based on the position information of the substrate stage 6 and the speed adjustment instructions output from the speed adjustment operating unit 18.

[0004]

[Problems solved by this invention]

However, because the B column 8 happens to vibrate at its natural vibration frequency, e.g., 50Hz, as effects from movements of the carriage 7 and vibrations of other deices are received, the control band of the aforementioned servo loop can only be set at a little over 10 Hz that is its 1/3 band to avoid oscillation. Therefore, the control performance of the servo loop cannot be increased because of this concern.

Concerning the above problems, the present invention has an object to provide a position detecting device that can increase the control performance of the stage without being effected by vibration of the reference unit for detecting the position of the stage, and an exposure device using the position detecting device.

[0005]

[Problem Resolution Means]

To resolve the above problems, as described in reference to Fig. 1 showing a preferred embodiment of this invention, a position detecting device of claim 1 detects positions of a stage (6) based on a light beam reflected on a fixed mirror (11) arranged in a reference unit (7) and a light beam reflected on a moving mirror (12) arranged on a movable stage (6), and is equipped with correction means (19) for correcting errors originated from vibrations of the fixed mirror (11) and control means (17) for controlling the stage (6) based on an output from the correction means (19).

[0006]

Moreover, for the position detecting device of claim 2, because the correction means is a low pass filter, effects of vibrations of the reference unit (7) can be eliminated from the stage control servo loop with simple constructions.

Furthermore, for the position detecting device of claim 3, the correction means (19) corrects the error based on a stage instruction signal instructing the driving of the stage (6), the

stage (6) can be controlled with presumption of the vibration of the reference unit (7) based on the stage instruction signal, and therefore, a high speed response becomes possible.

[0007]

In addition, the exposure device of claim 4 exposes a pattern of a mask (2) onto a substrate (5), is equipped with a mask stage (3) on which the mask (2) is placed and a substrate stage (6) on which the substrate (5) is placed. The aforementioned position detecting device is used for a position detecting device that detects a position of at least one of the mask stage (3) and the substrate stage (6).

Further, for the exposure device of claim 4, because an image of the pattern is projected on the substrate (5) by a projection optical system (4), and the fixed mirror (11) is arranged on the projection optical system (4), the position of the stage can be controlled with reference to the projection optical system (4).

[0008]

[Preferred Embodiment of the Invention]

A preferred embodiment of the present invention is described below with reference to FIG. 1. A complete schematic side view of a scanning exposure device of this preferred embodiment is shown in FIG. 1. The illuminating optical system 1 is fixed to the base 10 by means of the B column 8 integral with the base 10, and is constituted by including a light source, a light guide, fly's eye lens, a visual field stop, and condenser lens. The illumination light radiated from the light source of a super high pressure mercury lamp and the like is irradiated onto an illumination region on the mask 2 with uniform illumination distribution. The mask 2 is supported via a mask stage 3 in the upper portion of a carriage 7 of a U-shaped cross section. The mask 2 is minutely moved with respect to the carriage 7 integrally with the mask stage 3. The substrate 5, which is a rectangular glass plate coated with photoresist, is supported via a substrate stage 6 in the lower portion of the carriage 7, and the substrate stage 6 is supported to minutely move freely on the lower surface of the carriage 7. The carriage 7 is movably supported on a base 10 by air bearings or magnetic bearings, which are non-contact type bearings, and moves in the X direction in FIG. 2. In this embodiment, the carriage 7 is driven by a linear motor. A projection optical system 4 between the mask 2 and the substrate 5 projects an erect image at equal magnification and is fixed to the base 10 by means of the B column 8 (the fixed portions are drawn with thick lines, and the movable portions are drawn with thin lines). Because of this, the pattern (for example, the liquid crystal display element pattern)

on the mask 2 is exposed as an equal magnification erect image on the substrate 5 via the projection optical system 4. Then, by integrally scanning the mask 2 and substrate 5 by driving the carriage 7 in the X direction, the pattern on the mask 2 is sequentially exposed on the substrate 5. A laser interferometer 15 is supported on the A column 9, and by means of the interference of the light reflected from a fixed mirror 11 located in the projection optical system 4 and light reflected from a fixed mirror 13 located on the A column 9, the position of the projection optical system 4 referenced by the A column 9 is detected. The laser interferometer 16 is supported on the A column 9, and the position of the substrate stage 6 referenced by the A column 9 is detected by means of the interference of the light reflected from the moving mirror 12 arranged on the substrate stage 6 and the light reflected from the fixed mirror 14 arranged on the A column 9. The position information of the projection optical system 4 referenced by the A column 9 from the laser interferometer 15 and the position information of the substrate stage 6 referenced by the A column reference 9 from the laser interferometer 26 are brought into the main control device 30. Due to the movement of the carriage 7, the B column 8 vibrates at its natural frequency (for example, 50 Hz), and thus the position of the projection optical system 4, together with the fixed mirror 11 fixed to the projection optical system 4, are displaced due to the bending vibration of the B column 8. Because of this, the main control device 30 is equipped with a correction unit 19 which outputs the corrected position information of the projection optical system 4 based on the acceleration/deceleration calculation unit 18 which outputs a variable speed instruction according to the exposure program, and on the variable speed instruction and position information of the projection optical system 4, and a servo calculating unit 20 which calculates and outputs a drive signal of the carriage 7 based on the variable speed instruction and the position information of the substrate stage 6 output from the correction unit 19, and a drive amplifier 21 which amplifies the output of the servo calculating unit 20. The correction unit 19 corrects the position information of the projection optical system 4 referenced by the A column 9 according to the following equations:

[Equation 1]

$$Y_1(s) = \frac{2\pi f_1}{s + 2\pi f_1} \cdot X_1(S) \qquad (1)$$

$$W(s) = \frac{s^2 + s + (2\pi f_3)^2}{s^2 + cs + (2\pi f_2)^2} \qquad (2)$$

$$W^{-1}(s) = \frac{s^2 + cs + (2\pi f_2)^2}{s^2 |s| (2\pi f_3)^2} \qquad (3)$$

$$Y_2(s) = W^{-1}(s) \cdot X_2(s) \qquad (4)$$

$$Z(s) = a_1 Y_1(s) + a_2 Y_2(s) \qquad (5)$$

Where,

$X_1(s)$:	Laplace transform of position of projection of optical system 4
$X_2(s)$:	Laplace transform of acceleration instruction $x_2(t)$
$Y_1(s)$:	Laplace transform of $x_1(t)$ filter processed by low pass filter
$Y_2(s)$:	Laplace transform of $x_2(t)$ filter processed by second order filter
$W(s)$:	Bending vibration of B column 8
$W^{-1}(s)$:	Reciprocal of bending vibration of B column 8
$Z(s)$:	Laplace transform of corrected position $z(t)$ of projection optical system 4
f_1:	Cutoff frequency of low pass filter
f_2:	Bending resonant frequency of the B column 8 desired to follow
f_3:	Bending resonant frequency of the B column 8
a_1, a_2, c:	Appropriate weighting coefficients

[0009] In the correction unit 19 which corrects the position information of the projection optical system 4, Equation (1) shows the low pass filter with f_1 as a cutoff frequency with respect to the position $x_1(t)$ of the projection optical system, for example, in the case that the natural vibration frequency of the B column 8 is 50 Hz, taking for the cutoff frequency f1 = 17 Hz, the 50 Hz frequency component is eliminated. Therefore, even if the B column 8 vibrates at 50Hz which is its natural frequency, its effect is not exerted in the servo loop. Accordingly, even raising the servo control performance, the generation of the 50 Hz natural frequency of the B column 8 does not result. Moreover, the servo loop does not follow with respect to the natural frequency of the B column 8, but because the mask 2 and substrate 5 travel together with respect to the projection optical system 4, if scans are performed at a substantially uniform speed such that the amount of exposure becomes uniform, position setting of the projection optical system 4 with respect to the mask 2 and substrate 5 does not require high accuracy at a high frequency. That is, even if the position of the projection optical system 4 with respect to the

mask 2 and substrate 5 vibrates at a high frequency, the vibrations are averaged in the process of scanning process and impediments to the exposure result do not arise.

[0010] Equation (2) represents the bending vibration of the B column 8, and Equation (3) represents the reciprocal of the bending vibration of the B column 8. Because of this, Equation (4) represents the inverse system of the bending vibration of the B column 8 predicted with respect to the variable speed instruction $x_2(t)$ by means of this term it can become a high speed response system by feed-forward predicting the bending vibration of the B column 8 with respect to the variable speed instruction $x_2(t)$.

[0011] The output of the correction unit 19 responds quickly by taking the weighted average of the aforementioned two equations, as shown in Equation (5), without receiving the effect of the natural frequency of the B column 8, and yet by means of feed-forward from the variable speed instruction $x_2(t)$.

This invention is not limited to this embodiment.

The correction unit 19 may be a pure low pass filter having $a_2 = 0$, or may be a band stop filter instead of the low pass filter. Furthermore, with $a_1 = 0$, the bending vibration can be predicted based on the variable speed instruction.

[0012] The control unit 17 drives and controls the carriage 7 by means of the output of the drive amplifier 21. The laser interferometer 16, main control device 30 and control unit 17 constitute a servo loop, which provides following control of the carriage 7 and thus of the substrate stage 6, based on the variable speed instruction output from the variable acceleration/deceleration calculating unit 18, the position information of the projection optical system 4 referenced by the A column 9, and the position information of the substrate stage 6.

[0013] In the above construction, in order to first perform the positioning of the mask 2 and substrate 5, by moving the mask stage 3, a mask side alignment pattern formed on the mask and a substrate side alignment pattern formed on the substrate 5 are caused to coincide. Then, the carriage 7 is caused to scan and move at a uniform speed. By this means, the transfer and printing of the pattern region on the mask 2 onto the substrate 5 is completed.

The control unit 17, other than driving the carriage 7, may directly drive and control the substrate stage 6.

Servo calculating unit 20 may perform the actual calculation or may store and refer to an output table for inputs in a memory.

[0014] The stage which position is detected can be the mask stage 3 which positions the mask 2 of the exposure device, or the substrate stage 6 which positions the substrate 5.

A reference unit which arranges the fixed mirror 11 may be, other than the projection optical system 4, the illumination optical system 1, the A column 9, the B column 8, etc.

As the exposure device, the application can be made to an exposure device of the step and repeat type which exposes the mask 2 and the substrate 5 while each is stationary and causes successive step movements of the substrate 5, a proximity form of the exposure device which exposes the mask 2 and the substrate 5 while keeping them close to each other. In these devices, the variable speed instructions would be for stepping fine movements of position, and the like, which are all included to drive the stage(s).

[0015] The linear motor which drives the carriage 7 is constituted by a moving element (for example, a coil) and a fixed element (for example, a permanent magnet). If this fixed element is disposed in a frame insulated from vibration of the base 10, because the reaction force which arises during driving the carriage 7 transmits to the frame, it is transmitted only with difficulty to the base 10. Because of this, the vibration of the base 10 can be reduced.

[0016] The scanning type exposure device of this embodiment can be manufactured by performing optical adjustments of the illumination optical system 1, which has plural lenses and the projection optical system 4, and mounting on the carriage 7 the mask state 3 and substrate stage 6, which consist of numerous mechanical components, to perform overall control (electrical adjustment or operation confirmation, etc.) by connecting the main control device 30.

[0017] Moreover, not only a KrF excimer laser (248 nm), ArF excimer laser (193 nm), F2 laser (157 nm), but also X-ray and electron beam and the like charged particle beams can be used. For example, in the case of using an electron beam, as an electron gun, a lanthanum hexaboride (LaB_6), tantalum (Ta), thermionic emission type may be used.

[0018] The magnification of the projection optical system 4 may be a reduction system, equal magnification or enlarging system. Moreover, for the projection optical system 4, quartz or fluorite may be used as a glass material in the case of using an excimer laser, a catadioptric optical system can be used in the case of using X-rays (a reflecting type mask is also used), and, an electrooptical system consisting of electronic lenses and deflectors may be used as optical systems in the case of using an electron beam. Furthermore, the light path along which the electron beam passes is made vacuum.

[Efficacy of the Invention]

[0019] As described above, according to this invention, by means of removing from the servo loop which controls the movable stage the effect of vibration of the reference unit in order to detect the position of the stage, raising the stage control performance of the stage, resulting that the stage can be controlled at high speed.

[Brief Description of Drawings]

[Fig. 1]

FIG. 1 is a side view of a scanning exposure device of the present preferred embodiment; and

[Fig. 2]

FIG. 2 is a schematic diagram showing an example of a prior art scanning type exposure device.

[Description of Symbols]

1	Illumination optical system
2	Mask
3	Mask stage
4	Projection optical system
5	Substrate
6	Substrate stage
7	Carriage
8	A column
9	B column
10	Base
11, 13, 14	Fixed mirror
12	Moving mirror

[Name of Document] Abstract

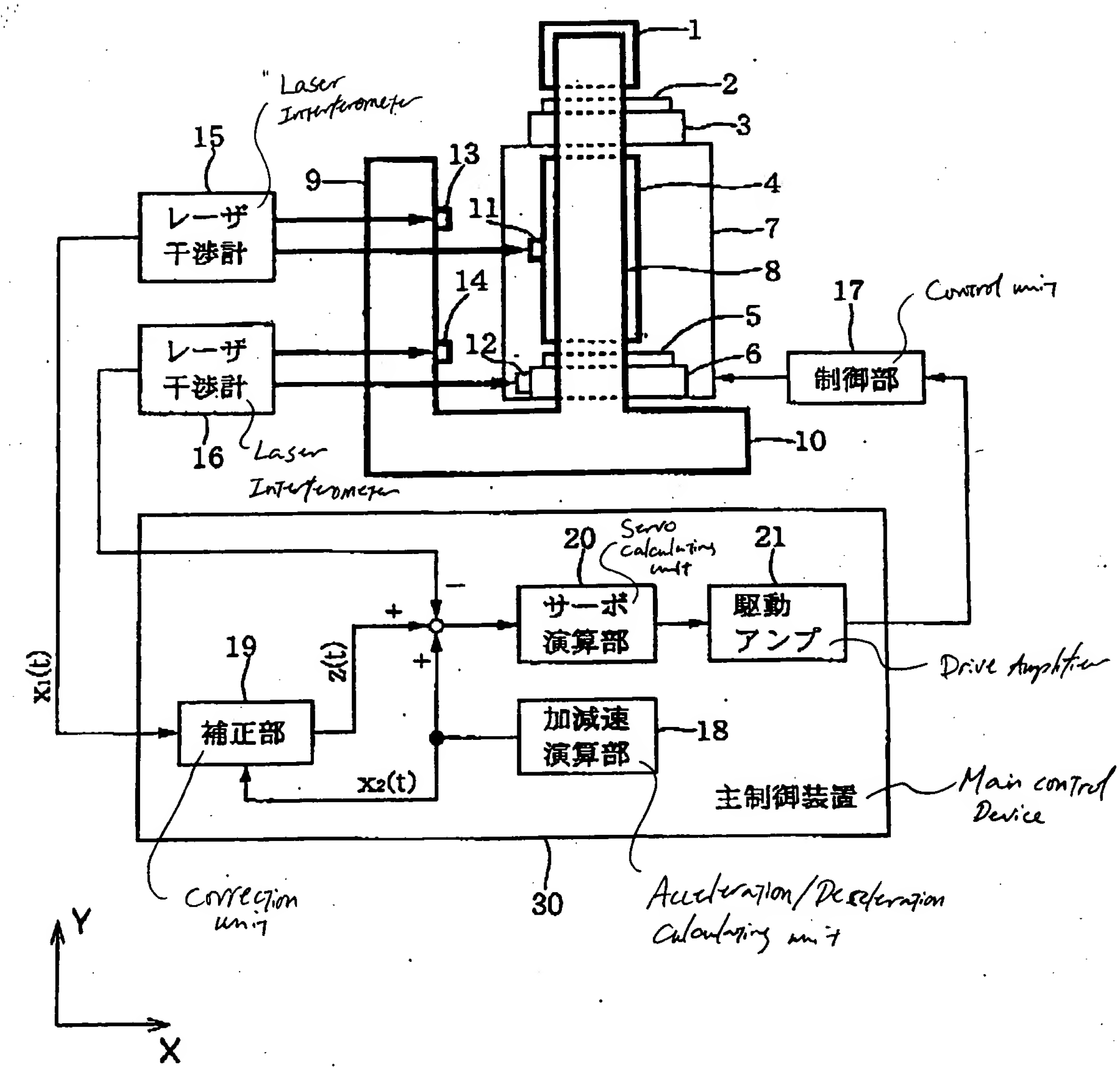
[Abstract]

[Object] To provide a position detecting device that can increase a control performance of a substrate stage 6 without receiving effects of natural vibrations of a projection optical system 4 being a reference for detecting the position of the substrate stage.

[Resolution Means] By detecting positions of the projection optical system 4 and the substrate stage 6, and by eliminating a natural vibration frequency component of the projection optical system 4 using a correction part 19 that is a low pass filter, the substrate stage 6 is controlled by a servo calculating unit 20, a drive amplifier 21 and a control unit 17. Therefore, no effects of the natural vibration frequency of the projection optical system 4 is applied to the servo loop that drives and controls the substrate stage 6, and the natural vibration frequency is not generated even if the control performance of the servo is increased. Accordingly, the substrate stage 6 can be controlled at high speed.

[Selective Figure] Fig. 1

Fig. 1


1
2
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16
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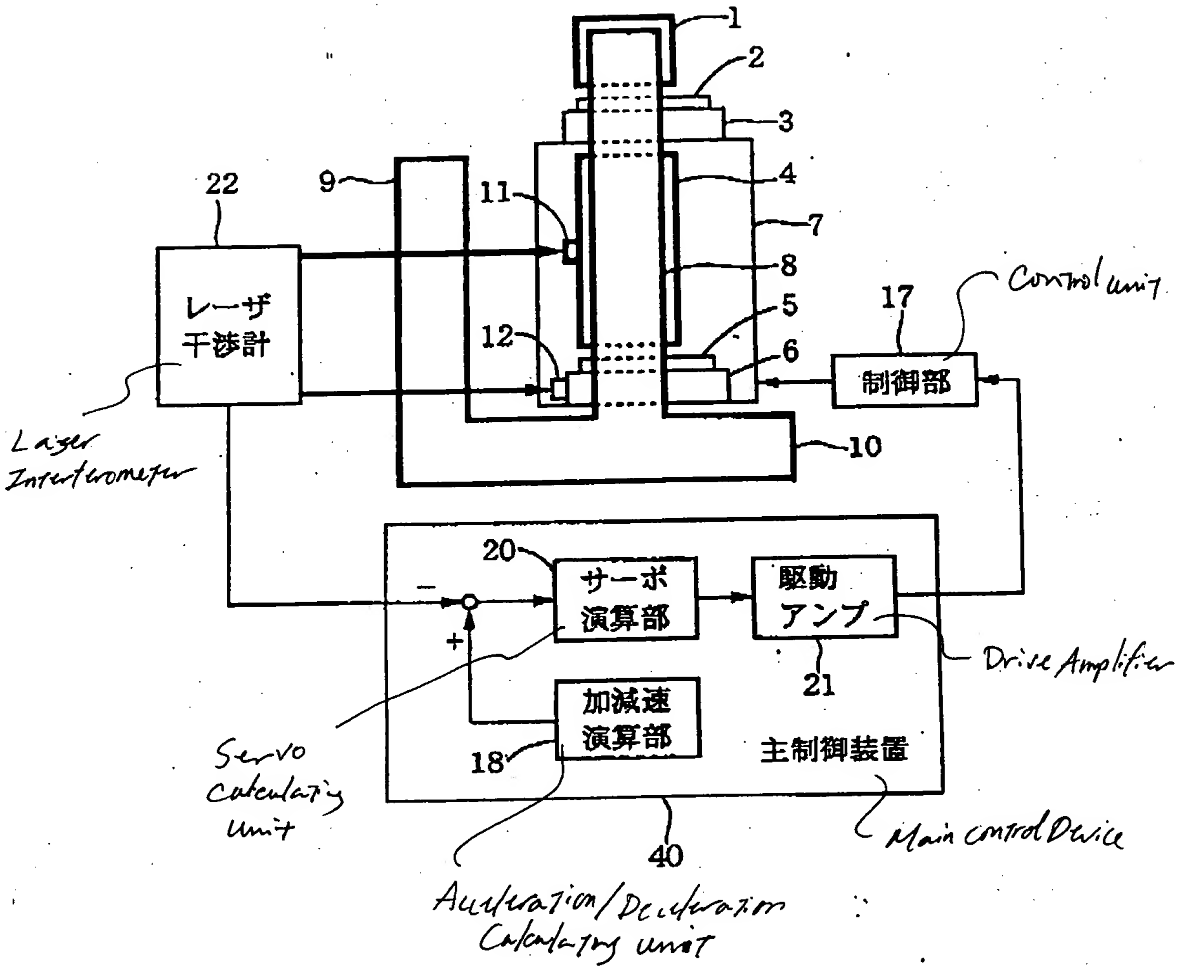
18
19
20
21
30
Laser Interferometer
レーザ干渉計
レーザ干渉計
Laser Interferometer
制御部
Control unit
サーボ演算部
Servo calculating unit
駆動アンプ
Drive Amplifier
補正部
Correction unit
加減速演算部
Acceleration/Deceleration Calculating unit
主制御装置
Main control Device
x1(t)
x2(t)
z(t)
+
+
−
Y
X

Fig. 2



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4
5
6
7
8
9
10
11
12
17
制御部
Control unit
22
レーザ
干渉計
Laser Interferometer
20
サーボ
演算部
Servo Calculating Unit
駆動
アンプ
21
Drive Amplifier
加減速
演算部
18
Acceleration/Deceleration Calculating unit
主制御装置
Main control Device
40
−
+